



Water quality characterization of District Morena (Madhya Pradesh, India): A comprehensive study

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Abstract

The present study was carried out to find out the water quality of District Morena, (M.P.) It is an agrarian area, dependent on groundwater resources. Agricultural and industrial runoff heightens the vulnerability of groundwater to contamination. Water quality index for different sampling stations was calculated for March 2024 to Feb. 2025. The results indicate that the water quality index of municipal tap water is better in comparison to bore wells and hand pumps water samples. In the present study in municipal tap water quality of sampling stations in Ambah and Porsa were found excellent and in all other sampling stations it was good. In hand pump and bore well water samples, water quality in Morena city, Ambah, Porsa and Jaura was found good, in Banmore it was poor and in Sabalgarh and Kailaras it was very poor.

Keywords: Water quality index, sampling station, municipal tap water, industrial run off

Introduction

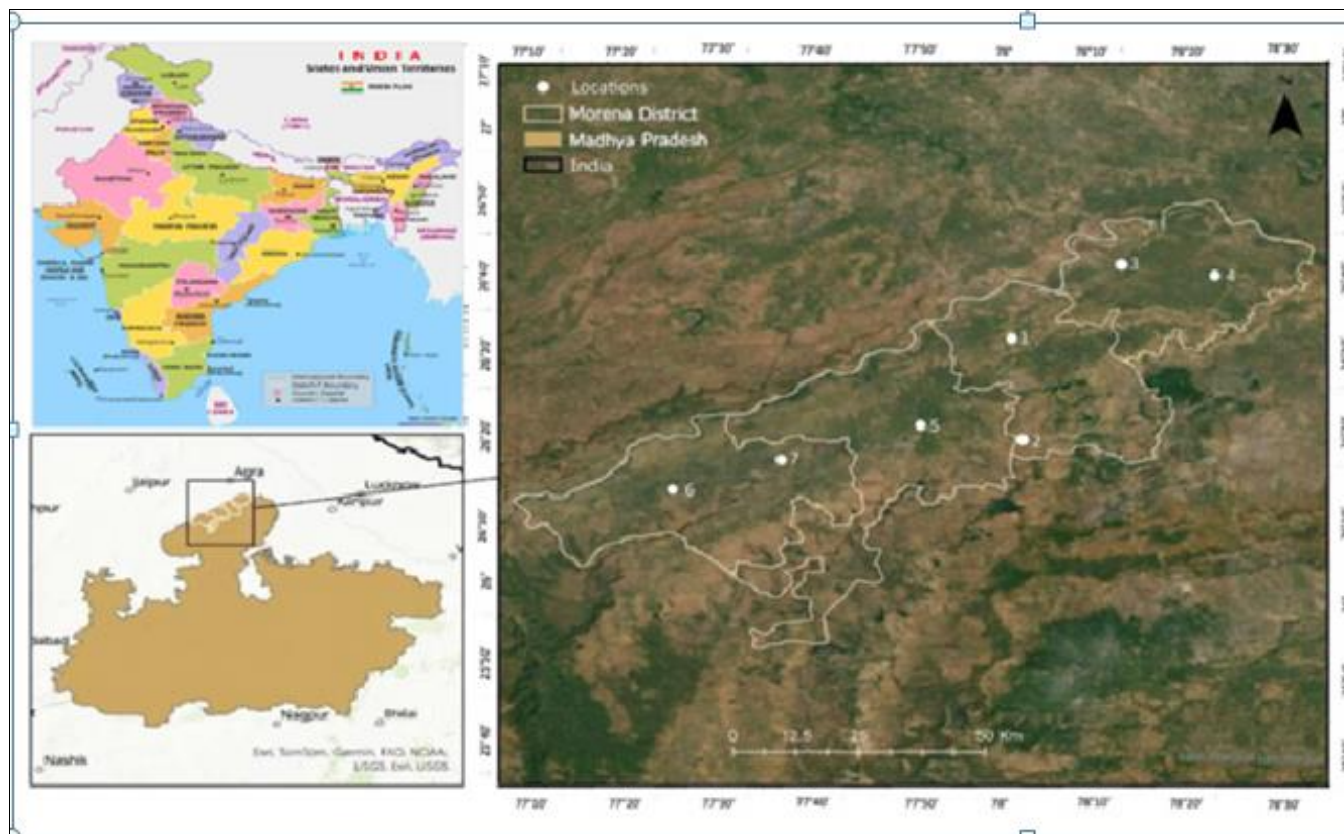
Water is an indispensable natural resource that sustains life, ecosystems, and economic activities. Safe drinking water is essential for life, health, and socioeconomic development. According to the United Nations, access to clean water is a human right recognized in international law (WHO 2022). Groundwater is the primary source of drinking water in both rural and urban areas of Morena. Hand pumps, tube wells, and bore wells are commonly used, often without adequate treatment. Limited municipal water supply infrastructure and irregular monitoring exacerbate the risk of exposure to contaminated water. However, the quality of groundwater is increasingly compromised due to geogenic and anthropogenic activities such as agricultural runoff, industrial discharge, improper waste disposal. In the present study, an attempt was made to assess the water quality in District Morena. By focusing on Morena, this study can contribute to the broader discourse on water resource management in semi-arid regions of India.

Material and Methods

Study Area

District Morena is located in the northern part of Madhya Pradesh, at 25°22' to 26°52' N latitude and 77°10' to 78°42' E longitude. The total area of Morena is 4989.78 Sq. km. and population of Morena is 1965137 (Census 2011)^[2]. The groundwater table of Morena city is approximately 120-180 ft. Climate is semi-arid and extreme weather conditions are present, summer temperature ranges from 45°C to 48°C

and winter temperature ranges from 4°C to 1°C. Morena receives average rainfall from 430 mm to 753.7 mm. Mainly alluvial deposits, sandstones, shales, and limestone make up the geology of this area which plays a significant role in determining groundwater chemistry. All 7 Tehsil places (of urban areas) in District Morena were selected for this study. They were depicted as Sampling Station 1 (S1)-Morena city, Sampling Station 2 (S2)-Banmore, Sampling Station 3 (S3)-Ambah, Sampling Station 4 (S4)-Porsa, Sampling Station 5 (S5)-Jaura, Sampling Station 6 (S6)-Sabalgarh, Sampling Station 7 (S7)-Kailaras. From every site samples of municipal (PHE-Public Health Engineering) tap water, hand pump water and bore well water were collected in triplicate. Physico-chemical analysis of drinking water sampling was done from March 2024 to Feb. 2025. Polyethylene bottles were properly labeled with sample number and cleaned with 5% nitric acid and rinsed with distilled water and allowed to dry before use. At sampling stations bottles were rinsed with sample water also. Hand pumps and tube wells were permitted to flow continuously for around 10 minutes before sample collection. The samples were immediately placed in dark boxes after collection and processed in the laboratory of SMS Govt. Model Science College Gwalior within 4 hours after collection for examination and analyzed for physicochemical parameters (pH, Electrical conductivity, TDS, Total alkalinity, Total hardness, Calcium hardness, Magnesium hardness, Sulphate) as per the standard methods of American Public Health Association (APHA 2023) and Trivedy and Goel (1987)^[1, 11].



Map 1-Sampling sites of District Morena (M.P.)

Result and Discussion

Table 1: Acceptable and permissible limits for drinking water as per BIS(IS10500:2012)

S.No.	Parameter	Acceptable limit	Permissible limit (In the absence of alternative source)
1	pH value	6.5– 8.5	No relaxation
2	Electrical conductivity, $\mu\text{S}/\text{cm}$	750	3000
3	Total Dissolved Solids (TDS), mg/L	500	2000
4	Total alkalinity, mg/L	200	600
5	Total hardness, mg/L	200	600
6	Calcium as Ca^{++} , mg/L	75	200
7	Magnesium as Mg^{++} , mg/L	30	100
8	Sulphate as SO_4 , mg/L	200	400

Table 2: Mean Value with standard error and range of variation in Physico-chemical Parameters in selected sites

Parameter		March 2024 – February 2025							
		pH	EC ($\mu\text{S cm}^{-1}$)	TDS (mg L^{-1})	TA (mg L^{-1})	TH (mg L^{-1})	CH (mg L^{-1})	MH (mg L^{-1})	SO_4 (mg L^{-1})
S1	PHE	7.25 $\pm$ 0.05	429.33 $\pm$ 6.36	258.00 $\pm$ 4.16	175.33 $\pm$ 6.96	179.00 $\pm$ 2.65	130.67 $\pm$ 5.55	48.33 $\pm$ 3.18	20.00 $\pm$ 0.89
		7.34-7.16	418.00-440.00	250.00-264.00	164.00-188.00	174.00-183.00	122.00-141.00	42.00-52.00	18.39-21.45
	HP	7.46 $\pm$ 0.06	1072.67 $\pm$ 19.88	644.00 $\pm$ 12.12	298.67 $\pm$ 13.04	386.33 $\pm$ 4.10	281.00 $\pm$ 6.24	105.33 $\pm$ 2.96	55.12 $\pm$ 1.19
		7.58-7.38	1048.00-1112.00	629.00-668.00	275.00-320.00	380.00-394.00	269.00-290.00	101.00-111.00	53.61-57.48
	BW	7.33 $\pm$ 0.05	1130.00 $\pm$ 20.82	677.67 $\pm$ 12.25	372.33 $\pm$ 7.69	382.33 $\pm$ 4.67	277.00 $\pm$ 5.20	105.67 $\pm$ 0.88	66.47 $\pm$ 2.15
		7.43-7.25	1090.00-1160.00	654.00-695.00	361.00-387.00	375.00-391.00	268.00-286.00	104.00-107.00	63.69-70.71
S2	PHE	7.39 $\pm$ 0.05	420.00 $\pm$ 18.93	253.00 $\pm$ 11.72	175.67 $\pm$ 7.80	182.00 $\pm$ 8.08	138.33 $\pm$ 4.91	43.67 $\pm$ 3.84	16.42 $\pm$ 0.59
		7.48-7.32	390.00-455.00	235.00-275.00	162.00-189.00	172.00-198.00	130.00-147.00	38.00-51.00	15.59-17.56
	HP	7.75 $\pm$ 0.05	1038.33 $\pm$ 13.02	623.33 $\pm$ 7.51	303.00 $\pm$ 9.64	415.00 $\pm$ 4.93	290.00 $\pm$ 11.85	125.00 $\pm$ 7.00	56.09 $\pm$ 1.19
		7.85-7.68	1015.00-1060.00	610.00-636.00	285.00-318.00	407.00-424.00	269.00-310.00	114.00-138.00	54.31-58.35
	BW	7.64 $\pm$ 0.06	1040.00 $\pm$ 27.54	626.33 $\pm$ 17.34	380.67 $\pm$ 8.19	410.33 $\pm$ 4.26	230.67 $\pm$ 7.13	179.67 $\pm$ 8.41	69.20 $\pm$ 1.79
		7.75-7.55	1010.00-1095.00	608.00-661.00	368.00-396.00	402.00-416.00	217.00-241.00	168.00-196.00	66.79-72.71
S3	PHE	7.05 $\pm$ 0.02	291.67 $\pm$ 4.41	175.00 $\pm$ 2.65	101.33 $\pm$ 8.29	107.00 $\pm$ 5.51	76.67 $\pm$ 6.33	30.33 $\pm$ 3.67	12.03 $\pm$ 0.93
		7.09-7.02	285.00-300.00	171.00-180.00	85.00-112.00	98.00-117.00	64.00-83.00	23.00-34.00	10.19-13.24
	HP	7.27 $\pm$ 0.06	415.00 $\pm$ 15.70	248.33 $\pm$ 8.82	182.33 $\pm$ 4.33	151.00 $\pm$ 3.46	92.67 $\pm$ 1.86	58.33 $\pm$ 1.86	39.84 $\pm$ 0.86
		7.35-7.15	392.00-445.00	235.00-265.00	175.00-190.00	145.00-157.00	89.00-95.00	56.00-62.00	38.29-41.25
	BW	7.41 $\pm$ 0.03	552.67 $\pm$ 16.29	331.33 $\pm$ 9.40	194.67 $\pm$ 7.75	195.00 $\pm$ 6.81	132.00 $\pm$ 2.08	63.00 $\pm$ 5.03	53.14 $\pm$ 0.86
		7.45-7.35	533.00-585.00	320.00-350.00	185.00-210.00	185.00-208.00	128.00-135.00	57.00-73.00	51.48-54.34

S4	PHE	7.08 ± 0.03	438.33 ± 13.02	265.00 ± 7.81	152.67 ± 11.67	167.67 ± 5.36	125.00 ± 3.21	42.67 ± 2.19	16.12 ± 1.17
		7.12-7.03	415.00-460.00	251.00-278.00	131.00-171.00	160.00-178.00	120.00-131.00	40.00-47.00	14.39-18.35
	HP	7.37 ± 0.03	576.67 ± 17.40	346.67 ± 9.60	239.33 ± 12.72	258.67 ± 8.11	171.00 ± 5.51	87.67 ± 3.67	21.15 ± 1.07
		7.42-7.33	545.00-605.00	329.00-362.00	218.00-262.00	244.00-272.00	160.00-177.00	84.00-95.00	19.29-22.98
	BW	7.27 ± 0.08	670.00 ± 8.66	402.67 ± 5.21	242.67 ± 5.81	276.33 ± 8.41	196.00 ± 8.96	80.33 ± 0.67	22.11 ± 0.99
		7.41-7.15	655.00-685.00	394.00-412.00	232.00-252.00	261.00-290.00	180.00-211.00	79.00-81.00	20.59-23.98
S5	PHE	7.16 ± 0.04	291.67 ± 7.26	174.67 ± 4.06	127.33 ± 8.01	120.33 ± 2.03	90.33 ± 3.76	30.00 ± 1.73	9.26 ± 0.64
		7.24-7.09	280.00-305.00	168.00-182.00	112.00-139.00	117.00-124.00	84.00-97.00	27.00-33.00	8.09-10.28
	HP	7.41 ± 0.08	826.67 ± 23.33	495.67 ± 12.91	213.00 ± 11.15	199.67 ± 6.12	149.00 ± 4.93	50.67 ± 1.20	46.40 ± 1.00
		7.56-7.31	790.00-870.00	476.00-520.00	192.00-230.00	190.00-211.00	141.00-158.00	49.00-53.00	44.67-48.13
	BW	7.45 ± 0.07	830.67 ± 10.97	499.33 ± 6.96	225.33 ± 8.19	210.33 ± 3.84	158.33 ± 4.48	52.00 ± 2.08	54.96 ± 1.48
		7.58-7.37	812.00-850.00	488.00-512.00	210.00-238.00	203.00-216.00	152.00-167.00	49.00-56.00	52.14-57.12
S6	PHE	7.37 ± 0.06	440.00 ± 28.87	265.00 ± 17.32	171.00 ± 9.07	192.00 ± 10.79	121.67 ± 0.88	70.33 ± 10.41	11.23 ± 0.58
		7.48-7.29	390.00-490.00	235.00-295.00	157.00-188.00	175.00-212.00	120.00-123.00	53.00-89.00	10.26-12.26
	HP	7.43 ± 0.05	1431.67 ± 23.15	859.67 ± 13.62	369.67 ± 14.62	484.67 ± 44.58	327.67 ± 28.29	157.00 ± 20.60	87.12 ± 4.26
		7.52-7.35	1390.00-1470.00	835.00-882.00	341.00-389.00	411.00-565.00	295.00-384.00	116.00-181.00	81.57-95.50
	BW	7.39 ± 0.09	1473.33 ± 22.05	885.67 ± 12.91	456.00 ± 15.10	599.33 ± 36.81	387.67 ± 19.23	211.67 ± 23.79	82.10 ± 1.45
		7.52-7.23	1440.00-1515.00	866.00-910.00	426.00-474.00	542.00-668.00	361.00-425.00	165.00-243.00	79.56-84.58
S7	PHE	7.07 ± 0.03	455.00 ± 11.55	272.67 ± 6.94	147.00 ± 8.72	177.33 ± 6.17	141.33 ± 2.96	36.00 ± 3.21	12.07 ± 1.21
		7.12-7.02	435.00-475.00	261.00-285.00	131.00-161.00	168.00-189.00	137.00-147.00	31.00-42.00	9.74-13.78
	HP	7.56 ± 0.06	1256.67 ± 19.65	755.67 ± 11.89	362.00 ± 9.87	488.33 ± 5.78	277.67 ± 5.36	210.67 ± 6.49	79.78 ± 2.44
		7.67-7.46	1230.00-1295.00	740.00-779.00	344.00-378.00	478.00-498.00	270.00-288.00	201.00-223.00	75.10-83.34
	BW	7.65 ± 0.08	1321.67 ± 23.33	793.33 ± 13.74	379.00 ± 10.69	496.33 ± 8.37	320.33 ± 6.17	176.00 ± 2.52	99.01 ± 1.54
		7.78-7.51	1285.00-1365.00	772.00-819.00	361.00-398.00	482.00-511.00	311.00-332.00	171.00-179.00	96.81-101.98

PHE-Municipal tap water, HP-Hand pump water, BW-Bore well water. EC-Electrical conductivity, TDS-Total Dissolved Solids, TA-Total Alkalinity, TH-Total Hardness, CH-Calcium Hardness, MH-Magnesium Hardness, SO₄-Sulphate.

- pH:** In tap water pH was observed from 7.02 to 7.42(highest –Sabalgarh, lowest-Porsa), in hand pump from 7.11 to 8.12(highest pH –Sabalgarh, lowest-Ambah), in bore well water from 7.18 to 8.15(highest -Kailaras, lowest- Ambah). all the samples were alkaline in nature. mishra (2011) ^[6] observed pH from 7.2 to 8.30 in Shivpuri Town. Pathak (2012) ^[7] reported pH between 7.44 to 8.65 and 6.51 to 8.37in Banda and Karrapur respectively, in Sagar (M.P.). Singh *et al.* (2026) ^[9] in Nalanda District South Bihar, found pH between 7.12 and 7.98, Shrestha *et al.* (2026) ^[8] reported pH of drinking water in Ramdhuni, Nepal variedfrom 6.44 to 6.90, with a mean of 6.64 ± 0.165 .
- ElectricalConductivity (EC):** For tap water EC was observed from 285 $\mu\text{S cm}^{-1}$ to 490 $\mu\text{S cm}^{-1}$ (highest-Sabalgarh, lowest- Ambah). for hand pump water it wasvaried from 392 to 1470 $\mu\text{S cm}^{-1}$ (highest-Sabalgarh, lowest –Ambah), for bore well water it was varied from533 to 1515 $\mu\text{S cm}^{-1}$ (highest-Sabalgarh, lowest-Ambah). Mishra (2011) ^[6] recorded EC in Shivpuri Town M.P. from 205 to 1350 μScm^{-1} which was almost similar to the present study. Singh *et al.* (2026) ^[9] in Nalanda District South Bihar India observed EC from436 to 2960 μScm^{-1} , higher in comparison to present study.
- Total Dissolved Solids (TDS):** For tap water was TDS was found from168 to 295 mg/ L (highest- Sabalgarh, lowest -Jaura), for hand pump water it was from 235 to 882 mg/L L (highest –Sabalgarh, lowest –Ambah), for bore well water from 320 to 910 mg L⁻¹ (highest – Sabalgarh, lowest –Ambah). Mishra (2011) ^[6]found TDS from 135 to 1080 mg/L in Shivpuri Town.Pathak (2012) ^[7] in Banda and Karrapur, Sagar (M.P.)observed TDS between 242.02 to 417.25 and 274.95 to 476.26 respectively, Singh *et al.*(2026) ^[9] in Nalanda District South Bihar,from 279 to 1894, Shrestha *et al.* (2026) ^[8] in Ramdhuni, Nepal from116.7 – 409 mg/L with a mean value of 217.54 ± 123.99 mg/L,almost similar to the values of present study.
- Total Alkalinity:** For tap water Alkalinity was found 85 mg/L to 230 mg/L (highest-Banmore, lowest-Ambah), for hand pump water it was from 175 to 389 mg/L (highest -Sabalgarh, lowest -Ambah), for bore well water it was 185 to 474 mg/L (highest –Sabalgarh, lowest -Ambah). All the values were under permissible limits of BIS.Mishra (2011) ^[6] reported 78 to 388 mg/L in Shivpuri Town, Pathak (2012) ^[7] in Banda and Karrapur, Sagar (M.P.) 105 to 325 and 104 to 278 respectively, values were almost similar to the present study. Shrestha *et al.* in (2026) ^[8] Ramdhuni Municipality Nepal found it from 8.5-28.9 mg/L. which was very low.
- Total Hardness:** For tap water it was ranged from 98 to 212 mg/L (highest -Sabalgarh, lowest –Ambah), for hand pump water from 145 to 565 mg/L(highest – Sabalgarh, lowest –Ambah), for bore well water from 185 to 668 mg/L (highest-Sabalgarh ,lowest – Ambah).All values were below permissible limits of BIS. Pathak (2012) ^[7] studied drinking water status in Banda and Karrapur, Sagar (M.P.) and observed total hardness between 153.34 to 295.56 and 150.19 to 268.06mg/L respectively, Singh *et al.* (2026) ^[9] in NalandaSouth Bihar, from 145 to 725mg/L, Mishra (2011) ^[6] from 35 to 530 mg/L in Shivpuri Town.All these values were in accordance with the present study.
- Calcium Hardness:** For tap water it was observed from 64 to 147 mg/L(highest –Kailaras, lowest -Ambah), for hand pump water from 89 to 384 mg/L,(highest - Sabalgarh ,lowest -Ambah), for bore well water from 128 to 425 mg/L, (highest -Sabalgarh ,lowest – Ambah).Mishra (2011) ^[6]found calcium hardness

from 10 to 105 mg/L in Shivpuri, Pathak (2012) [7] in Banda and Karrapur, Sagar (M.P.) from 113.16 to 226.45 and 114.36 to 209.05 mg/L respectively. Singh *et al.* (2026) [9] in Nalanda District South Bihar, India from 16 to 174 mg/L. Shrestha *et al.* (2026) [8] in Ramdhuni, Nepal found mean value (122.74 ± 83.76) mg/L, which were almost similar to the present study.

7. Magnesium Hardness: For tap water magnesium hardness was ranged from 23 to 89 mg/L (highest-Sabalgarh, lowest –Ambah), for hand pump from 49 to 223 mg/L (highest-Kailaras, lowest- Jaura), for bore well from 49 to 243 mg/L (highest –Sabalgarh, lowest-Jaura). Mishra (2011) [6] found magnesium level from 0.4 to 42 mg/L in Shivpuri Town, Pathak (2012) [7] in Banda Karrapur, Sagar (M.P.) from 16.48 to 75.19 and 18.77 to 75.27 mg/L respectively. All these levels were low in comparison to the present study. Singh *et al.* (2026) [9] in Nalanda District South Bihar, found magnesium from 4 to 81 mg/L, which was very low.

8. Sulphate: For tap water in Sulphate was ranged from 8.09 mg/L to 21.45 mg/L (highest-Morena city, lowest – Jaura), for hand pump water from 18.29 to 95.5 mg/L (highest –Sabalgarh, lowest –Porsa), for bore well water from 20.59 to 101.98 mg/L, (highest-Kailaras, lowest –Porsa). Mishra (2011) [6] found Sulphate from 01 to 55 mg/L in Shivpuri Town, Singh *et al.* (2026) [9] in Nalanda District South Bihar, India

from 2 to 217 mg/L, which were high in comparison to the present study.

Water Quality Index: Water Quality Index, is rating reflecting the composite influence of different water quality parameters on the overall quality of water (Deininger and Maciunas, 1971) [3]. It was first proposed by Horton (1965) [5]. In this method cumulative and composite effects of each element are analyzed. It is calculated to get information about suitability of water for human consumption, to monitor water quality changes in a particular water source over time lapse, for comparison of qualities of different water supplies in the same region or from different regions of the world.

Table 3: Classification of water quality and status based on weighted arithmetic WQI Method

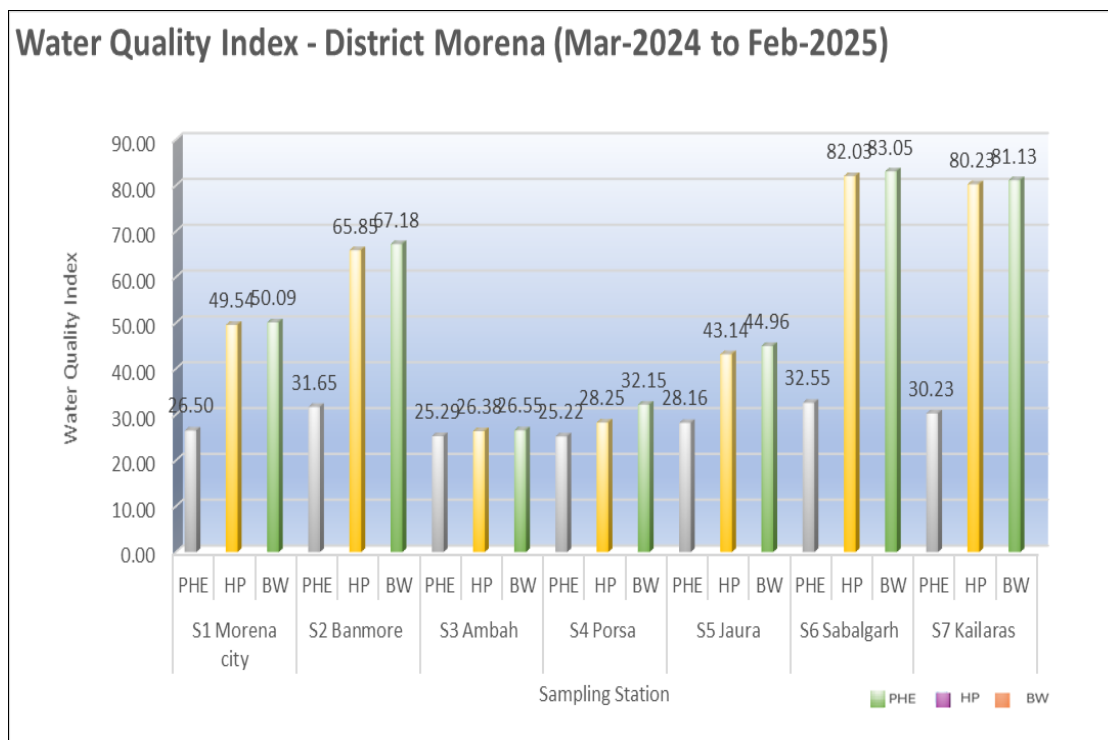
Water Quality index	Status
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
>100	Unsuitable for drinking

Source: Brown *et al.* (1972)

Result- On the basis of the calculations the WQI of various sampling stations were determined. For all the calculations standard values of BIS (IS 10500;2012) were taken into consideration.

Table 4: Water Quality Index of Different sampling sites in District Morena (2024-25)

S. No	Sampling Station	PHE (Municipal Tap water)	Hand Pump water	Bore well water
1.	Morena city	26.50	49.54	50.09
2.	Banmore	31.65	65.85	67.18
3.	Ambah	25.29	26.38	26.55
4.	Porsa	25.22	28.25	32.15
5.	Jaura	28.16	43.14	44.96
6.	Sabalgarh	32.55	82.03	83.05
7.	Kailaras	30.23	80.23	81.13



Conclusion

In the present study in municipal tap water quality of sampling stations in Ambah and Porsa were found excellent and in all other sampling stations it was good. In hand pump samples, water quality in Morena city, Ambah, Porsa and Jaurawas good, in Banmore it was poor and in Sabalgarh and Kailaras it was very poor. Bore well water quality of Morena, Ambah, Porsa and Jaura was found good while in Banmore it was poor and in Sabalgarh and Kailaras it was very poor. PHE department or municipality supply water after treatment in purification/filtration plant, so all the parameters were present in almost controlled limits. Groundwater is more protected but geological influences and geochemical processes, substantial anthropogenic pressures such as mining, industrial discharge, agricultural runoff, and improper waste disposal are responsible for the elevated level of contaminants. So the findings of the present study highlighted need to strengthen water safety measures, routine monitoring, improved treatment technologies and to address pollution at the source.

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Conflict of Interest-There is no conflict of interest.

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